SkySync

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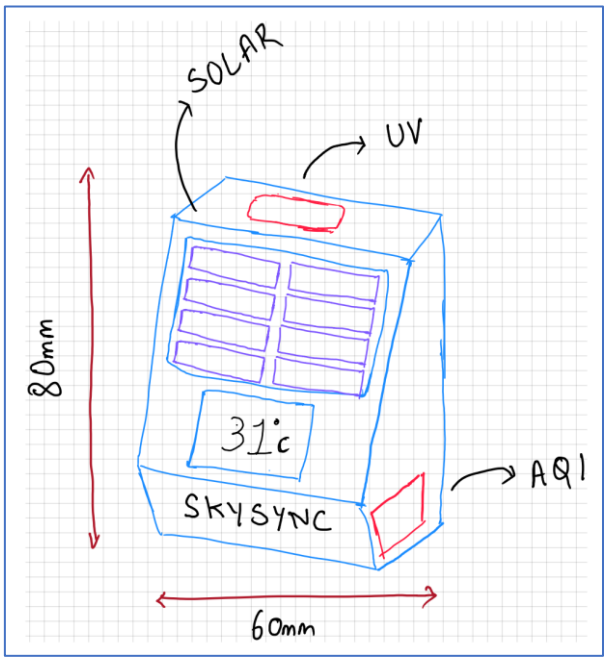
SkySync: A Personal Weather Station

In today's rapidly evolving data-centric ecosystem, data isn't just pivotal – it's transformational. Our ability to make informed decisions, whether in our personal lives or professional domains, largely rests on the accuracy and timeliness of the data we collect. Enter SkySync, a personal weather station tailored for the modern user. Unlike traditional weather stations which are fixed and bulky, SkySync is portable, user-friendly, and designed to seamlessly integrate with your daily activities.



1: Napkin Sketch of how it might look.

Unique Value Propositions

- **On-the-Go Environmental Intelligence**: Whether you're an outdoor enthusiast embarking on a hike or a biker embracing the wilderness, SkySync can be effortlessly attached to your backpack, ensuring that you're always aware of the environmental conditions around you. Tracking metrics like UV Exposure (UVA, UVB, UVC), Air Quality (eCO2, VOCs), temperature, pressure(altitude) & humidity.
- **Indoor vs Outdoor Comparative Analysis**: Why rely on generic weather reports when you can measure real-time indoor conditions and juxtapose them with the outdoors? With SkySync, you gain insights into how external weather impacts your indoor environment, allowing for optimized comfort and energy savings.
- **Geo-Tagged Data Collection:** With an integrated companion app, every data point SkySync captures is geo-tagged. This not only allows users to understand climatic variations across different terrains and locations but also allows creation of a rich database for deeper environmental analysis.
- **Sustainable Energy:** SkySync incorporates solar cells for energy harvesting. This ensures extended usage without the need for frequent recharges, and more importantly, minimizes the carbon footprint.
- **Personal Safety Alerts**: Beyond just data collection, SkySync offers actionable insights. If a sudden drop in temperature is detected or a storm seems imminent, SkySync, via its companion app and hardware features like beeper, will send real-time alerts ensuring you're never caught off guard.

Block diagram

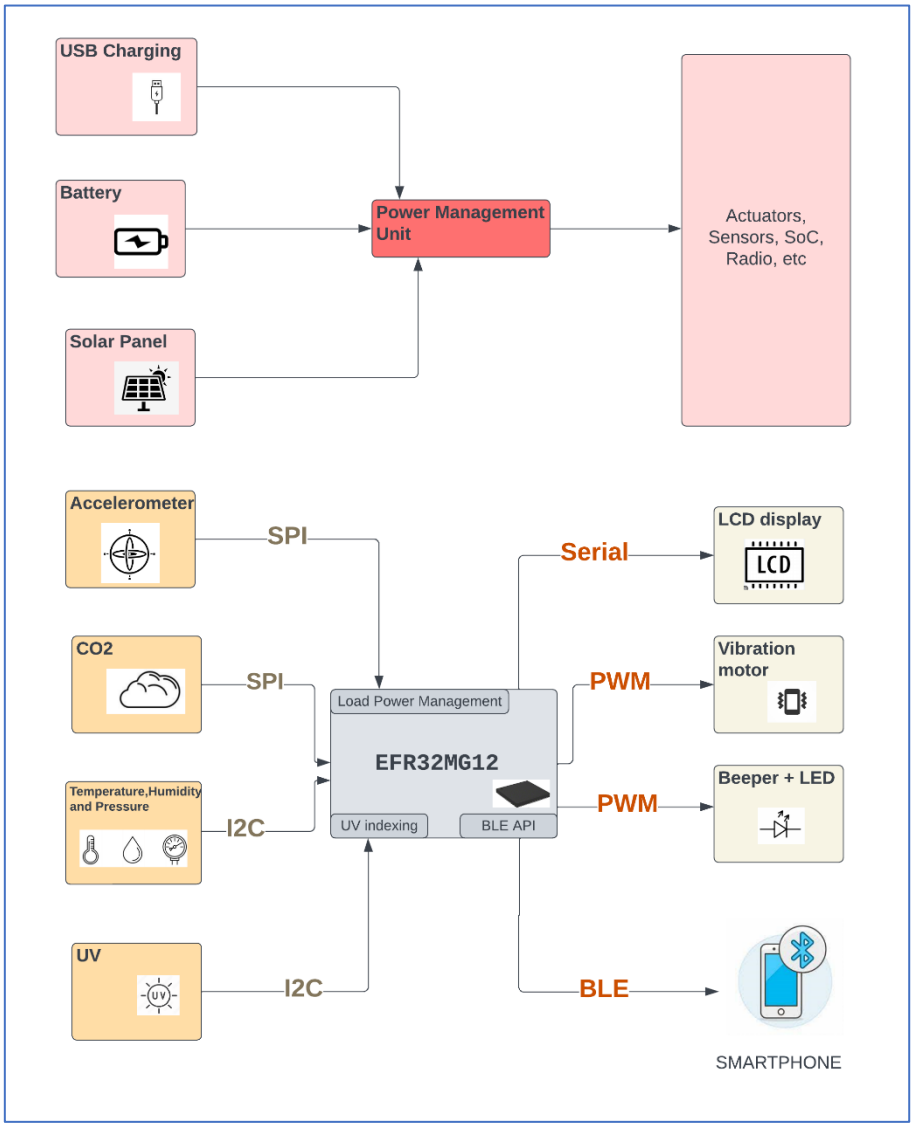


Figure 2 System Block Diagram

This complex EFR32MG12 SoC-based system serves as a sophisticated environmental monitoring platform. It amalgamates data from ENS160, BME280, and AS7331 sensors to provide comprehensive insights into air quality, weather conditions, and UV radiation exposure. Users can access this data through a low-power LCD display or remotely via a smartphone connected through BLE. Additionally, the vibration motor enhances user interaction by providing tactile feedback or alerts, contributing to a holistic and user-friendly experience.

Product Features

Air Quality Index (AQI): The ENS160 sensor will be integrated into our weather application to provide real-time air quality data. Users can access up-to-the-minute air quality information, allowing them to make informed decisions based on the latest data. When used in combination with other data, such as CO2 and VOC levels, the ENS160 sensor can contribute to assessing indoor air quality, which is important for occupant health and comfort.

UV Index: The AS7331 is a low-power, low noise integrated UV sensor. A "Spectral UVA/B/C Sensor" typically refers to a sensor that can measure different segments of the ultraviolet (UV) light spectrum, specifically UVA, UVB, and UVC. The three separated UVA, UVB and UVC channels convert optical radiation signals via photodiodes to a digital result and realize a continuous or triggered measurement.

Load power management: We will be utilizing the MC3419 accelerometer to assess user activity through linear motion, and we are dynamically adjusting the product's measurement frequency based on detected activity levels to optimize data collection and power efficiency. During more intense activities like hiking, the station measures data more frequently and provides it to the user. More intense activities usually entail faster dynamic weather environments.

Temperature, Humidity and Pressure: In our weather station project, we will integrate the BME280 sensor to precisely measure temperature, barometric pressure, and humidity levels in nearby surroundings. This sensor enables us to provide accurate and real-time meteorological data, enhancing the reliability and functionality of our weather monitoring system.

Smartphone app: We're employing Bluetooth Low Energy (BLE) technology to seamlessly transmit real-time weather data from our monitoring station to nearby smartphones. This wireless connection allows users to conveniently access up-to-the-minute weather information on their local smartphone, enhancing their ability to make informed decisions based on current environmental conditions.

Haptic feedback: We will integrate a vibration motor into our system to provide timely alerts to users in the event of adverse weather conditions or deteriorating air quality. This haptic feedback mechanism ensures that users are promptly notified of critical environmental changes, enhancing their safety and awareness.

Display: We're incorporating a low-power LCD display (Sharp 128x128 LS013B7DH03) into our weather station to efficiently showcase real-time weather data at periodic intervals. This energy-efficient display ensures that users can effortlessly access up-to-date meteorological information while maximizing battery life in our portable weather monitoring solution.

Product Specifications

- **CO^2**: Measure VOCs and Carbon Dioxide between Excellent conditions (~400 ppm) to Bad conditions (>1500 ppm) with accuracy of ±15%.
- **Ultraviolet**: UV Index from 1-11+ according to Erythermal Action Curve.
- **Battery Life**: Up to 12 hours of active mode battery life on a single charge, up to 72 hours in low power mode.
- **Activity detection**: Detect and distinguish between low activity levels and high activity levels to better manage energy.
- **Temperature and Pressure:** Measures temperature from the range -40°C to 85°C with accuracy of ±0.5°C and pressure from the range below sea level (300 hPa) to Mt. Everest (1100 hPa) with accuracy of ±2 hPa.
- **Connectivity**: Sync to smartphone app over BLE with range of up to 10 mts.

Extended Features and Stretch Goals

These are some of the additional hardware, firmware & software features we want to implement based on project timeline and challenges.

- **NFC Quick Pairing:** Using passive or active NFC tags, implementing quick BLE pairing using NFC as OOB data.
- **PM2.5 Particulate Matter Measurement**: Particulate Matter addon sensor which can be attached to the main device for improved AQI numbers.
- **Swappable Solar Panel**: Swap to a bigger solar panel when device is stationed.
- **Additional App Features:** Notifications on App, GPS tagging and additional visualization.
- **Cloud Dashboard:** Data storage on cloud and visualization.
- **User Button:** Cycle through all the metrics on the display.
- Simultaneous App Communication with multiple portable weather stations.

Challenges

Miniaturization: Designing compact and portable weather monitoring equipment that houses multiple sensors while maintaining accuracy can be challenging. The nature of sensors, for example UV sensor, which requires a wide field of view to capture the incoming light, will put constraints on the layout of the board. It cannot be placed next to bulky components which limit its view. The solar cells also have similar requirements. This poses a challenge in being able to place all components on the PCB without compromising any of their functionality.

Power Management: Our portable weather stations run on batteries and solar energy. Additionally, due to moving parts (vibration motor) and the nature of some exotic sensors (UV sensor) the peak current drawn at times could come very close to, or exceed, the max current pushed by the PMIC. Balancing power efficiency with data accuracy is a challenge.

UV: In our research, we found a sensor which gives us UV A, B and C spectral values. But this is not equivalent to the UV index that can be readily used. It would be a challenge to map these spectral values to the UV index and thus determine the harmful range.

Sensor Calibration: Ensuring the accuracy of sensor readings is essential for a weather station. Calibrating sensors like UV sensor and CO2 sensor and maintaining calibration over time due to sensor aging can be challenging, as environmental conditions can affect sensor performance.

Data Transmission: Transferring data from the product to a local smartphone poses challenges in terms of pairing and maintaining BT connections. As the BLE radio consumes power for every transmission, finding the sweet spot between conserving energy and providing the user data regularly becomes critical.

Environmental Protection: Weather stations need to withstand various environmental conditions, including rain, humidity, and temperature extremes. Designing a robust and weather-resistant enclosure is crucial for long-term outdoor use. A 3D printed case with adequate protection might be necessary.

Cost Management: Weather has a lot of parameters, and each factor needs a sensor of its own to measure it. Developing a portable weather station with high-quality sensors and features can be expensive. Additionally, we will have to make choices between going for a more critical environment factor for a costlier sensor versus going for multiple less-impactful environmental factors with cheaper sensors.

Testing and Validation: Rigorous testing and validation under different weather conditions is necessary. Figuring out a way to simulate these conditions, without causing any harm to any member of the team, will be tricky. Fortunately, residing in Boulder, CO, we experience all sorts of weather conditions and that makes this challenge slightly easier to navigate.

Component Selection and Specifications

SYSTEM FUCNTIONS	COMPONENT	WEBSITE LINK	DATASHEET & Digikey Part Number	Dimension	COST
SoC	MIGHTY GECKO	EFR32MG12P432F1024GM48-C	DATASHEET 336-4227-ND	7mm x 7mm	11.79
BATTERY	LI-ON BATTERY	ASR00036	DATASHEET 1832-1052-ND	48.0mm x 30.0mm x 6.0mm	6.37
ENERGY HARVESTING	SOLAR CELL	SM111K10L	DATASHEET SM111K10L-ND	42.0mm x 35.0mm x 2.0mm	9.39

SYSTEM FUCNTIONS	COMPONENT	WEBSITE LINK	DATASHEET & Digikey Part Number	Dimension	Interfaces	Current/Power Consumption	Operating voltage	COST (USD)
SENSORS	MC3419 *Backup (ADXL343)	MC3419	DATASHEET 3502-MC3419CT-ND	2 mm × 2 mm × 0.92 mm	I2C SPI	• Standby current 4 µA • WAKE state current 77 µA	1.7 V to 3.6 V	1.66
	BME280	BME280	DATASHEET 828-1063-1-ND	2.5 mm x 2.5 mm x 0.93 mm	I2C SPI	• 1.8 µA @ 1 Hz humidity and temperature • 2.8 µA @ 1 Hz pressure and temperature • 3.6 µA @ 1 Hz humidity, pressure and temperature • 0.1 µA in sleep mode	1.71 V to 3.6 V	6.42
	ENS160	ENS160	DATASHEET 2618-ENS160-BGLMCT-ND	3 mm x 3 mm x 0.9 mm	I2C SPI	• DEEPSLEEP mode 0.01 mA • IDLE mode 2 to 2.5 mA • STANDARD mode 29 mA	1.71 V to 1.98V	10.2
	AS7331	AS7331	DATASHEET 4991-AS7331_MOLGA16LFT&RDPCT-ND	2.6 mm x 3.65 mm	I2C	• Active mode during measurement 1.5to 2 mA • Standby state 970 µA • Power down state 1 µA	2.7 V to 3.6 V	10.8
ACTUATORS / OUTPUTS	DISPLAY	LS013B7DH03	DATASHEET 425-2903-ND	23.0 mm x 23.04 mm	Serial	• 12-130 uW	2.7 V to 3.3 V	11.9
	VIBRATION MOTOR	VCLP1020B002L	DATASHEET 1670-VCLP1020B002L-ND	Dia (10.00mm)		• Max 30 mA	2.5 V to 3.5 V	2.12